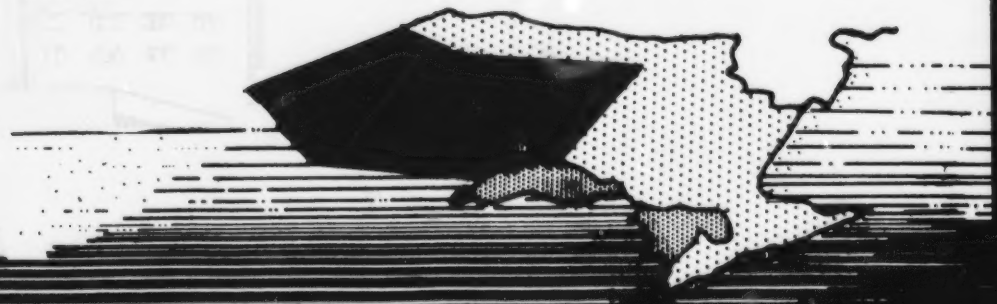

Ministry of Natural

NORTHWESTERN ONTARIO FOREST TECHNOLOGY DEVELOPMENT UNIT

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CAN WE USE THE NORTHERN PRIME LAND CLASSIFICATION TO IDENTIFY THE PRODUCTIVITY OF JACK PINE SITE IN NORTH CENTRAL ONTARIO?

by

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ABSTRACT

In 1985 the Northern Region, Ontario Ministry of Natural Resources, developed a classification and key for assigning various soil-site conditions to relative site productivity classes. This key was developed using selected soil site variables considered to be critical in influencing individual tree and stand growth. A total of three primary classes (i.e. Prime, Intermediate, and Non-prime) and eleven sub-classes of site productivity for all species was developed.

The question remaining to be answered is "Can we use the same key and classification system for identifying site productivity in north central Ontario for selected species?". This investigation tested the accuracy of the Northern Region Prime Land key in predicting jack pine site productivity in north central Ontario. An extensive data base consisting of 84 plots established by the Forest Ecosystem Classification (FEC), and 99 plots from Schmidt's (Schmidt and Carmean 1988) soil-site study for jack pine in the North Central Region was used. Site productivity was described using site index (height of dominant trees at breast height age of 50 years).

Northern Region soil classes/sub-classes did not stratify the plots into separate and distinct ranges of jack pine site productivity which were significantly different from each other. Considerable variation in site productivity occurred within each prime land (sub)class, except prime land (sub)class 3^{vs}, which is defined as a shallow soil less than 30 cm deep.

It is recommended that the Northern Region prime land key not be adapted for use in the north central Ontario, since it fails to accurately and consistently distinguish significant differences in jack pine site productivity. The key must be drastically altered, or a different soil classification key/system developed for prime land classification in north central Ontario.

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INTRODUCTION

Forest managers need site productivity (a.k.a. prime land) classification systems to assist them in making objective planning and management decisions about where, when and to what extent, management activities should occur (Carmean 1975, 1977, 1987). In addition to a knowledge of site productivity, land classification and yield prediction are also necessary tools in establishing production targets and objectives (Figure 1).

There is a continuing need for well planned timber management activities to maintain or enhance the future flow of fibre in northern Ontario. It is estimated that the availability of preferred conifer fibre from the natural forest to supply Thunder Bay mills will be depleted in 50 years. Furthermore, these mills will then be totally dependent upon the new forest which is being established today (Squires 1988). Accordingly, the long-term economic stability of northern Ontario will be dependent upon the continued production of high quality wood from the most productive sites at a cost which will yield reduced future wood costs and/or desired level of return on investment (Thrower 1986).

Intensive timber management activities should be concentrated on productive or "prime" lands, as these soil conditions are often more responsive to management practices, and can produce greater and better yields on shorter rotations (Carmean 1977, 1987). Intensively managing the most productive soil/sites requires methods for identifying these productive areas within the wide diversity of site quality found across most boreal forest areas.

In practice, previously harvested stand volumes or the forester's knowledge and experience are often used as a means for identifying the best site conditions for future investment levels. However, many sites can have a higher potential productivity than that which is indicated by the current stand condition. This is especially true for NSR backlog, recent cutovers, partially

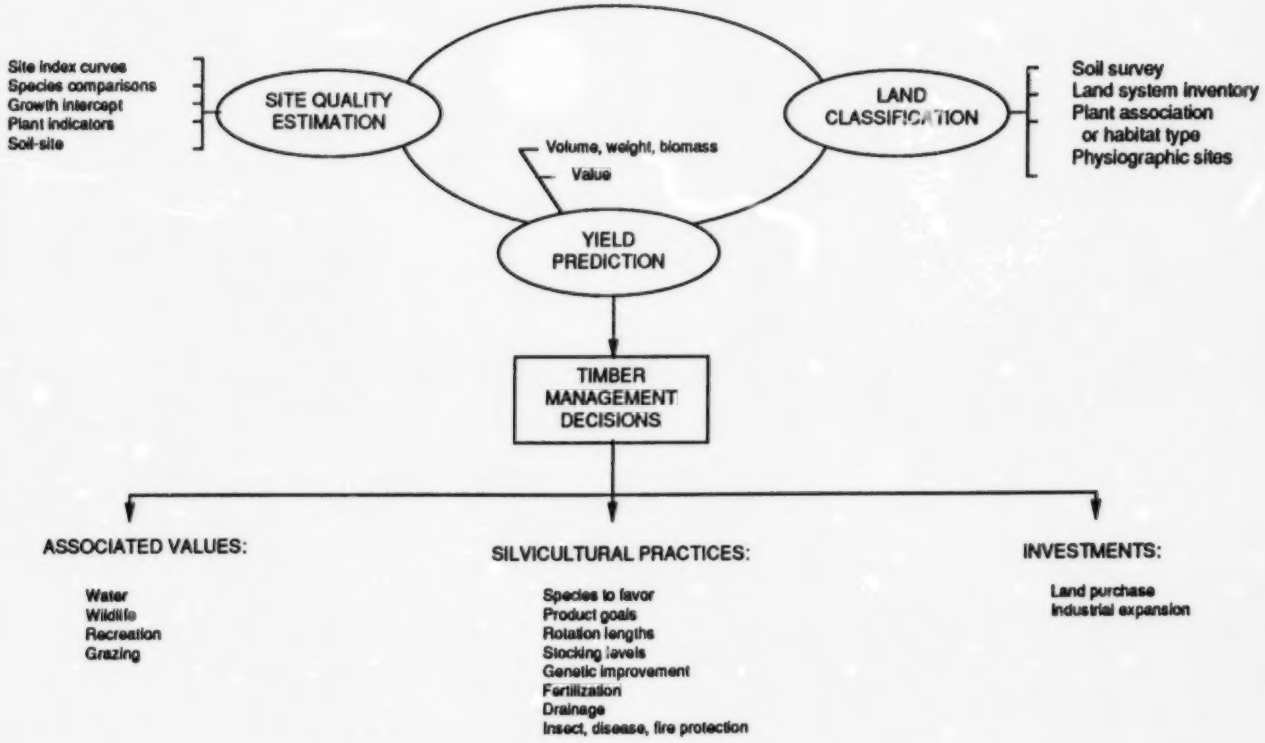

Figure 1. Decisions about intensive forest management depend upon a complimentary framework of site quality estimation, yield prediction, and forest land classification (Carmean 1977).

harvested areas, and areas that are not sufficiently regenerated. In addition, scaling records or opinions of an experienced forester are not always available or reliable at the time when the harvesting and regeneration prescription is being made.

Currently, the Northern Region prime land key (Figure 2) is the only objective, soils-based method in Ontario for ranking relative site productivity (Nicks 1985). It has been proposed that this prime land classification should also be applied to north central and northwestern Ontario (Figure 3), after possible modifications for local site conditions (Towill and White 1987). Although the classification and key suggests that there should be parallel quantitative differences between sub-classes, the classification was not originally based on quantitative data. Rather, it was based on soil features judged to be significant to the growth of all four major tree species: 1 jack pine (Pinus Banksiana) Lamb.); 2 black spruce (Picea marina (Mill.) B.S.P.); 3 white spruce (Picea glauca (Moench) Voss); and 4 aspen (Populus tremuloides Michx.).

OBJECTIVE

1. To verify the accuracy and reliability of the Northern Region, OMNR, prime land classification for distinguishing significant difference in jack pine site productivity between soil/site conditions of North Central Ontario.

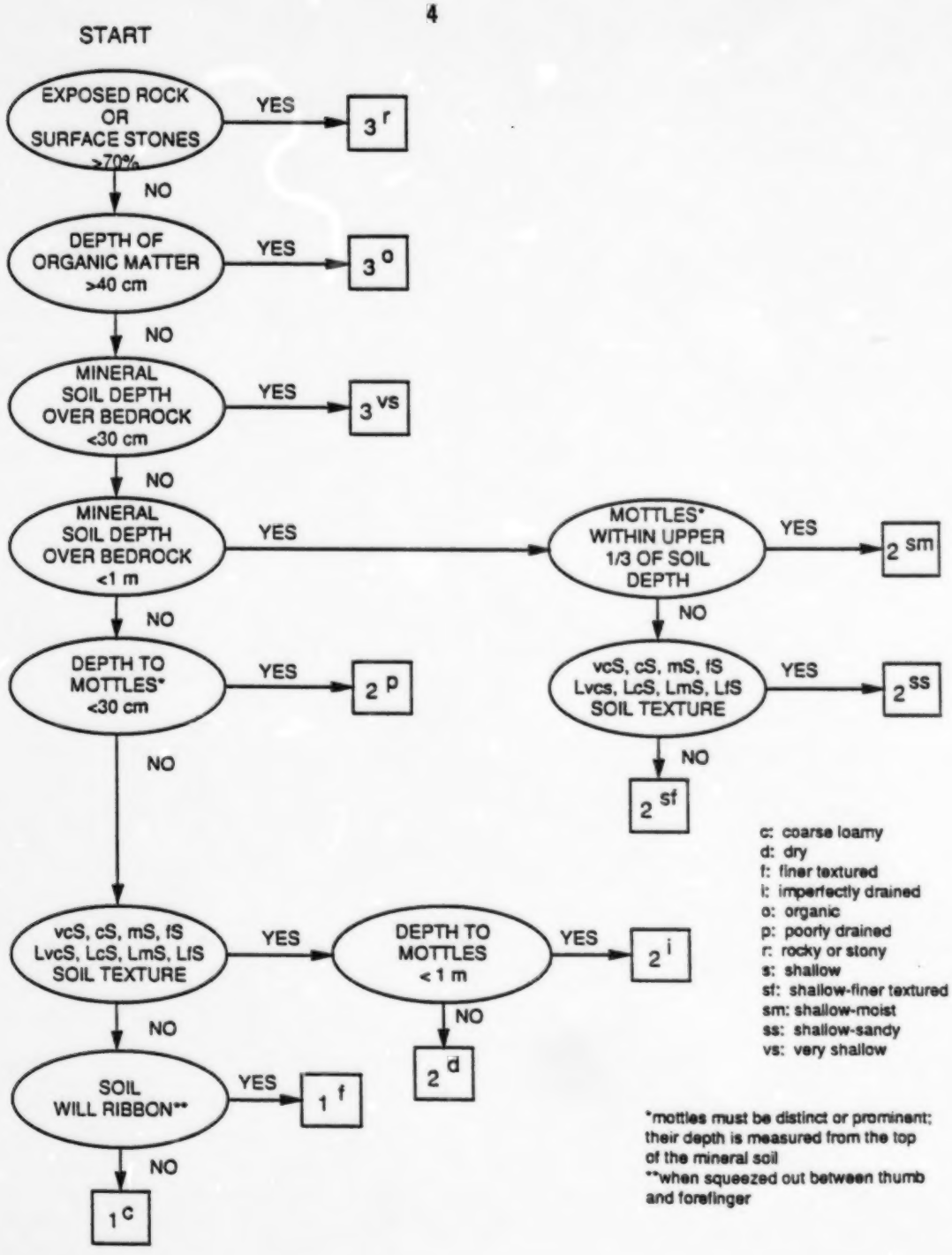

Figure 2. Northern Region prime land classification and key (Nicks 1985, Jones 1986).

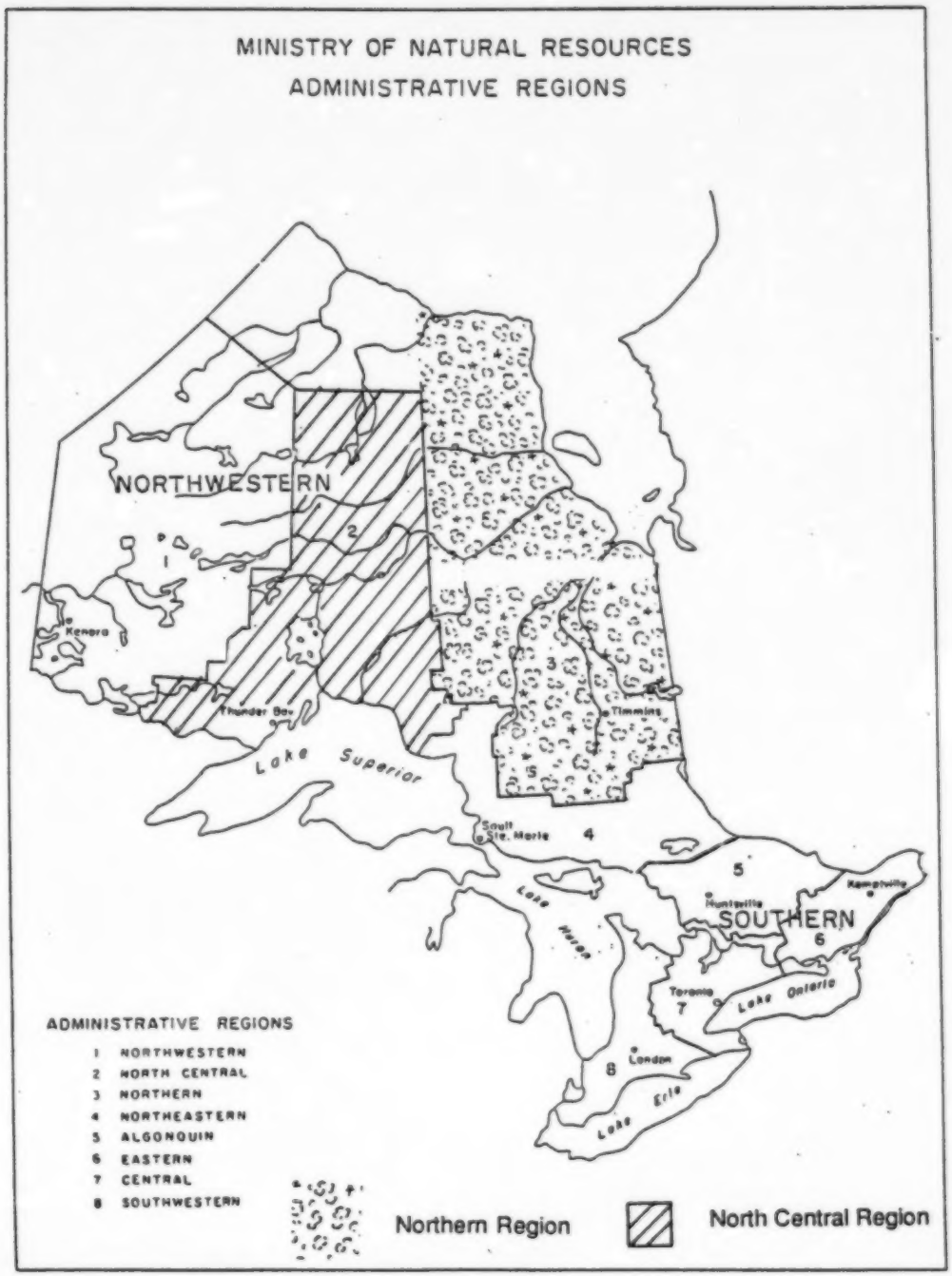

Figure 3. Northern, North Central and Northwestern Regions, Ontario Ministry of Natural Resources.

LITERATURE REVIEW

Origin of Prime Land Management

Prime land management began as prime farmland conservation in the United States. The concern over the loss of highly productive and unique cropland arose from the loss of 9.31 million hectares of cropland (3.24 million hectares of prime land) that was converted to urban, highway, and water uses between 1967 and 1975 (Schmude 1977). Prime and unique farmland is defined by the United States Department of Agriculture as follows:

> "Prime farmland is land that has the best combination of physical and chemical characteristics for producing food, feed, forage, fibre, and oilseed crops, and is also available for these (the land could be cropland, pastureland, rangeland, or other land but not built-up land or water). In addition to the criteria above, site location and adjacent uses and other economic and social factors will be given due consideration."
>
> "Unique farmland is land other than prime farmland that is used for the production of specific high value food and fibre crops. It has the special combination of soil quality, location, growing season, and moisture supply needed to economically produce sustained high quality and/or high yields of specific crops when treated and managed according to acceptable farming methods. Examples of such crops are citrus, tree nuts, olives, cranberries, fruit, and vegetables."

Prime farm land was valuable, as it accounted for a large share of crop yields grown, and produced higher average yields at a lower cost than other cropland (Schmude 1977). Prime land was also considered the most responsive to management (e.g. fertilization) and required the least investment for maintaining productivity. Less productive land produced lower yields, had higher costs, and increased environmental hazards such as erosion. If the United States wanted to maintain long-term agricultural capability at the lowest cost to the economy and the landscape, then prime lands had to be retained as cropland (Schmude 1977).

Concerns over prime farmland management then led the United States Department of Agriculture (USDA) to examine the long-term implication of various land-use options on Federal projects that diverted prime land to other uses. In 1973, the Secretary of Agriculture established the Planning and Policy Committee for Land Use and Land Conservation. This committee coordinated the interests and responsibilities of the Department to assure that land was used for the greatest long-term benefit of all people. A seminar on the retention of prime lands was sponsored by the USDA committee on land use in 1975. The seminar provided the USDA with the background information necessary for consideration of national policy objectives regarding prime lands.

Criteria for the identification of prime lands was based entirely on soil characteristics and other physical criteria. The system of prime land management was set up to facilitate the identification and inventory of productive farmland in a reasonable time by using existing soil surveys. Factors such as market location, transportation, and facilities are useful in making land decisions, but these fluctuating variables do not affect the intrinsic productive quality of the land. As a result, these economic factors were not included in the prime farmland criteria (Roget 1976).

Prime Land Classification for Timber Management

In 1973, the Secretary of Agriculture issued a "Statement on Land Use Policy". The main policy issue of adapting present pertinent programs to help enhance and preserve prime agricultural land against the loss of prime timberland was adopted, as a concern in the U.S., by land managers and foresters. Zivnuska and Vaux (1975) recognized that 11 percent of the U.S. forest land was prime (i.e. produced greater than 5.9 cubic metres per hectare

year^{-1}) and that these prime forest lands represented 21 percent of the U.S. wood growing capacity.

A Prime Forest Lands Subgroup was developed to undertake the task of defining prime timberland. The criteria used to distinguish prime timberland was that of potential productivity. The group agreed that the use of soils data and physiographic characteristics would be to define Prime Forest Land, because not all prime timberland had timber present for measuring productivity.

Prime and unique timberland was defined by the USDA (1978) as follows:

> "Prime timberland is land that has soils capable of growing wood at the rate of 5.94 cubic metres per hectare year^{-1} at culmination of mean annual increment (site 3 or better) in natural stands, and is not in urban or in built-up land uses or in water. Generally speaking, this land is land currently in forest, but does not exclude qualifying lands that could realistically be returned to forest".
> "Unique timberlands are lands which do not qualify as prime timberland on the basis of producing less than 5.94 cubic metres per hectare year^{-1}, but are growing sustained yields of specific high value species or capable of producing specialized wood products under a silvicultural system that maintains soil productivity and protects water quality."

Acknowledging the necessity for intensive forest management, Zivnuska and Vaux (1975) estimated that less than one-third of commercial forest land was productive enough to be managed intensively. Therefore, efforts should be made to avoid loss of the prime timber areas that are best suited for intensive forest management. The national standard of 5.94 cubic metres per hectare year^{-1} represents 34 percent of commercial timberland (Roget 1976).

Implementation of a program to identify prime timberlands was to be carried out on a local level by correlating soil features to stands that contained greater than 5.94 cubic metres per hectare year^{-1}.

Prime Land Identification in Ontario

In 1984, the Northern Region, Ontario Ministry of Natural Resources, (OMNR), produced guidelines for the identification of prime lands for forest management. The purpose of these guidelines was to provide timber managers with objective, efficient guidelines for classifying soil productivity (Nicks 1984).

A preliminary soil productivity key was drafted by a Prime Site Committee in 1984. Since soil features were considered the dominant indicator of site productivity (primeness), soil features were used in the key. This key was not based on any site productivity data, but instead reflected soil features that were considered to be important for tree growth. Obvious features distinguishing lower productivity sites (i.e. Non-Prime class 3) occurred first in the key, followed by more detailed depth, soil texture, and mottling estimates for recognizing the more productive sites (i.e. Prime and Intermediate classes 1 and 2). Three major categories of site productivity were recognized on the basis of overall commercial species growth:

Class 1-Prime Land
Class 2-Intermediate Land
Class 3-Non-prime Land

Sub-classes were then formed within each major class to identify the nature of the site, and to distinguish species suitability. Only one sub-class per major class was permitted and no multiple sub-classes occurred. These sub-classes are indicated on the key as a superscript to the major productivity class, eg.

c - coarse loamy
s - shallow
f - finer textured
i - imperfectly drained
o - organic
p - poorly drained
r - rocky or stony
d - dry
sf - shallow-fine textured
sm - shallow moist
ss - shallow sandy
vs - very shallow

The key was designed specifically for site conditions in northern Ontario, and was intended to be simple, flexible, practical, and cost-efficient. As a result, the key employed only five soil/site criteria: 1) exposed rock or surface stone, 2) depth of organic matter, 3) depth of mineral soil, 4) depth to mottles, and 5) soil texture. These five criteria were considered to be very significant to tree growth in northern Ontario.

Unfortunately, species suitability by productivity class was not clearly identified. The three broad classes of productivity represented a composite estimate of suitability for all major commercial species in northern Ontario (i.e. black spruce, jack pine, white spruce, and trembling aspen) (Nicks 1984). No further detail could be added since there was a lack of soil/site or stem analysis data for each of the four species. Thus, none of the prime land classes are capable of defining specific ranges of site productivity as defined by measures of site index (dominant height at age 50 years breast height) for any of the four tree species.

Intended uses of the final product were as follows:

1) harvest scheduling;
2) road location;
3) silvicultural prescriptions;
    -forecasting stock requirements by species, age, and grade;
    -site preparation planning;
    -forecasting tending requirements;
    -predicting yields and rotations lengths;
    -assessment of input costs, revenues, and return on investment; and,
4) transfer of site-specific technology.

Robinson et al. (1987) tested the predictive ability of the Northern Ontario Engineering Geological Terrain Study (NOEGTS), Ontario Land Inventory (OLI), and Agriculture Canada soil maps to identify the prime land soil classes and sub-classes in northwestern Ontario. It was determined that the NOEGTS 1:100,000 maps were generally unsuitable for identification of prime lands, as the soil/site information attached to each polygon were not sensitive to the criteria used in the prime land key. The NOEGTS maps had been originally designed as road engineering interpretations for the identification of sources of aggregates, and difficult and problem terrains. The reliability of the NOEGTS to predict prime land class was found to vary from eight to 40 percent accuracy.

In contrast the OLI maps at a scale of 1: 250 000 identified land units or landtypes. Robinson et al. (1987) considered that the OLI data could predict prime land class and sub-class much better that NOEGTS. However, no statistical analysis of their accuracy was completed.

Likewise, Agriculture Canada soil maps were found unsuitable for predicting prime land class and sub-class (Robinson et al. 1987). These 1:50,000 maps had polygon description which were not sensitive to the criteria used in the prime land soil key. In addition, the map series did not provide coverage for the entire geographical area.

Difference between Prime Land and Prime Site Management

There are important differences between prime land and prime site management. Prime land is land which grows commercial tree species better than other sites, due to the capability of the soil to provide moisture, aeration, and nutrients for tree growth (Towill and White 1987). In contrast, prime site

management is the overall managing of specific forest lands for the highest return on investment (Towill and White 1987). The highest return on investments can be made for example, by intensively managing the sites that are closest to the mill, for the highest valued species, using the shortest rotation, and on the most productive land. Thus, prime site management is based on not only soil productivity (prime land productivity), but also on the economics of transportation, access, regeneration, tending and maintenance, wood supply, and prices (Figure 4).

Note that prime land management is based on the relatively fixed measure of soil productivity, while prime site management is based on many additional economic components. These variable additional components could cause the management statue of forest lands to change each time a change occurred in the economics of one of the components.

Thus, prime land management is only one of several components of prime site management. <u>However, it is imperative that the identification of prime land be accurate, otherwise prime site management is also inaccurate and not effective</u>.

METHODS

Study Area

The study area is the North Central Region, OMNR. This area lies immediately northwest of Lake Superior, and extends from west of Atikokan to east of Manitouwadge and Marathon and extends 125 km north of Lake Nipigon (Figure 3).

North Central Ontario is characterized by a wide diversity in geology, soils, climate, and vegetation. The region encompasses Rowe's (1972) B.8, B.9,

mainly ground moraines, followed by lacustrine deposits and shallow to bedrock soils (Day et al. 1986). Outwash and aeolian deposits are common, with minor portions of eskers and end moraines also of common occurrence.

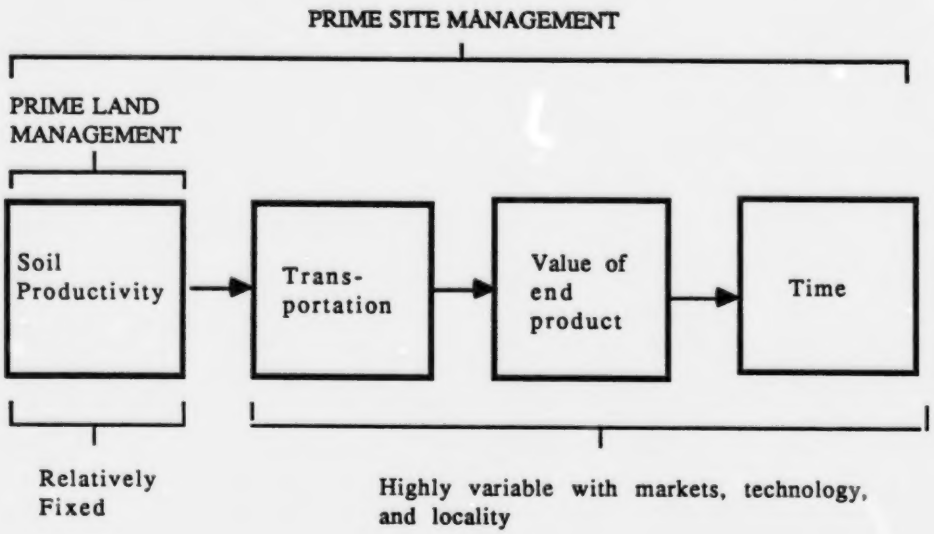

Figure 4. Contrast and comparison of prime land and prime site management.

Data Origin

Jack pine site productivity and soil/site data were obtained from 84 plots established by Forest Ecosystem Classification (FEC) program in jack pine dominated stands (Sims et al. 1989). Fifty-eight of the FEC plots were located in pure, even-aged jack pine stands, while the remaining plots occurred in jack pine-dominated mixedwood stands. Total height and breast-height age data for three or more dominant and codominant trees on each plot were used to calculate an average site index value for the jack pine using Carmean and Lenthall (1989 equation) for predicting site index of jack pine trees greater than 20 years

equation) for predicting site index of jack pine trees greater than 20 years breast-height age. Site index (dominant height of trees at age 50 years breast height) was used as the measure of site productivity. Landform and complete soil profile description were also available for each plot.

Data from an additional 99 plots located in even-aged jack pine were obtained from Schmidt's (1986) data base. Each plot description contained soil profile information, and an average site index value for the jack pine based on stem analysis of three or more dominant and codominant trees.

Testing Site Index within the Northern Region Prime Land Classes

All 183 plots were pooled into one dataset (i.e. 84 FEC plots and 99 Schmidt plots). On the basis of the individual plot soil/site data, each plot was then assigned to a prime land soil sub-class using the Northern Region prime land key (Figure 2). For each soil sub-class the mean, range, standard deviation, standard error, and confidence interval of the jack pine site indices were calculated. A Student's 't' approximation (Steel and Torie 1980) was used to test for significant differences in the average jack pine site index values between the different soil sub-classes. Soil sub-classes 2^{p} (poorly drained) and 2^{i} (imperfectly drained) were combined into a single class for analysis purposes.

RESULTS

Site Index Variability within the Northern Region Prime Land Classes

Prime land sub-class 3^{vs} was the least productive class, and displayed the smallest average jack pine site index values of all sub-classes (Table 1). It was also statistically different from all other primeland sub-classes (Figure 5 and 6). Prime land sub-classes 2^{sf} and 2^{sc} were significantly different from

a limited number of the other prime land sub-classes. The remaining prime land soil classes, (i.e. 3^r, 2^{sm}, 2^{ss}, $2^p/2^i$, 2^d, 1^f, and 1^c) did not have significantly different average jack pine site index values (Figure 5). Scatter plots and confidence intervals for individual plot jack pine site index value stratified by prime land soil sub-classes are also displayed on Figure 6.

Table 1. Site index values jack pine in north central Ontario stratified by Northern Region prime land (sub)-classes.

Soil class	No. plots	Mean (m)	Observed range (m)	Standard deviation	Standard error mean
3r	2	17.2	14.8-19.8	3.54	2.50
3vs	20	12.3	8.55-17.1	2.89	0.65
2sf	13	15.8	13.2-18.8	1.66	0.46
2sm	3	17.1	15.7-18.4	1.33	0.77
2ss	7	15.8	14.0-17.1	1.28	0.48
2p/2i	22	17.4	15.2-20.5	1.67	0.36
2d	37	17.3	12.6-22.4	2.36	0.39
1f	25	18.1	13.6-20.8	1.68	0.34
1c	45	17.6	11.9-21.0	1.83	0.27

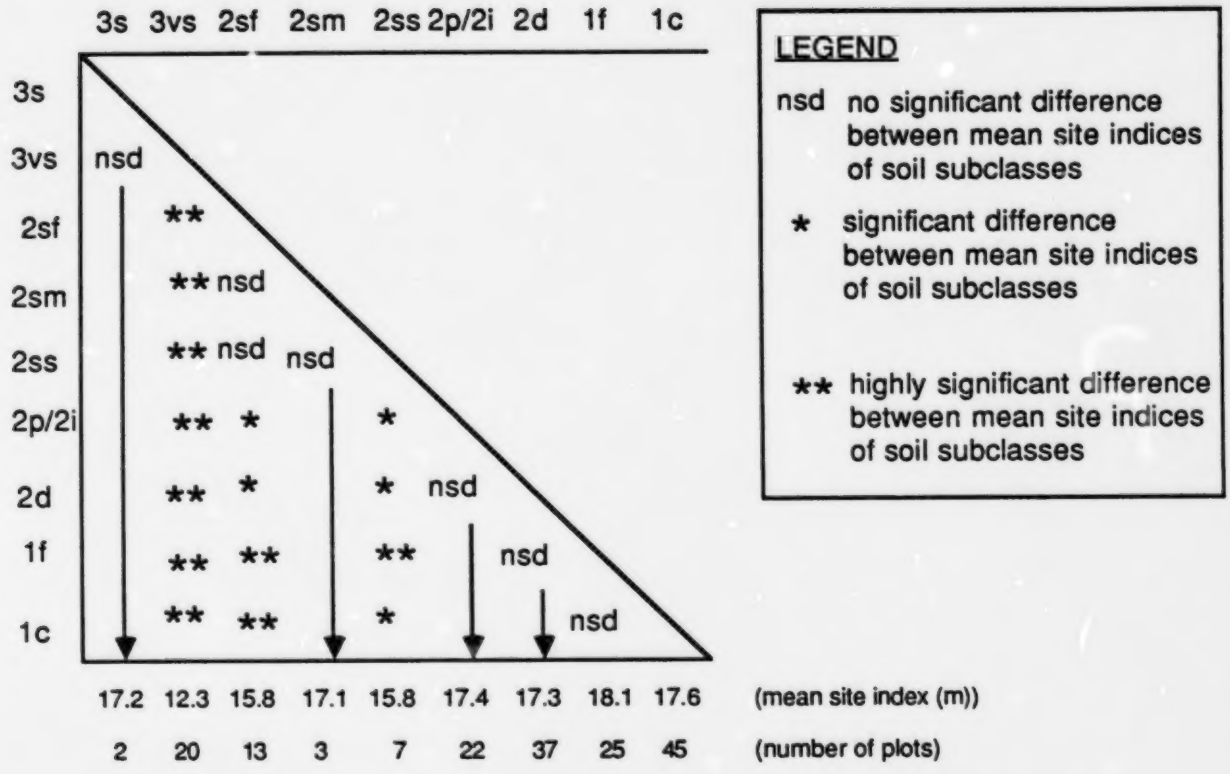

Figure 5. Student's 't' approximation summary chart showing occurrence of significant differences in observed average jack pine site index values between prime land (sub-) classes.

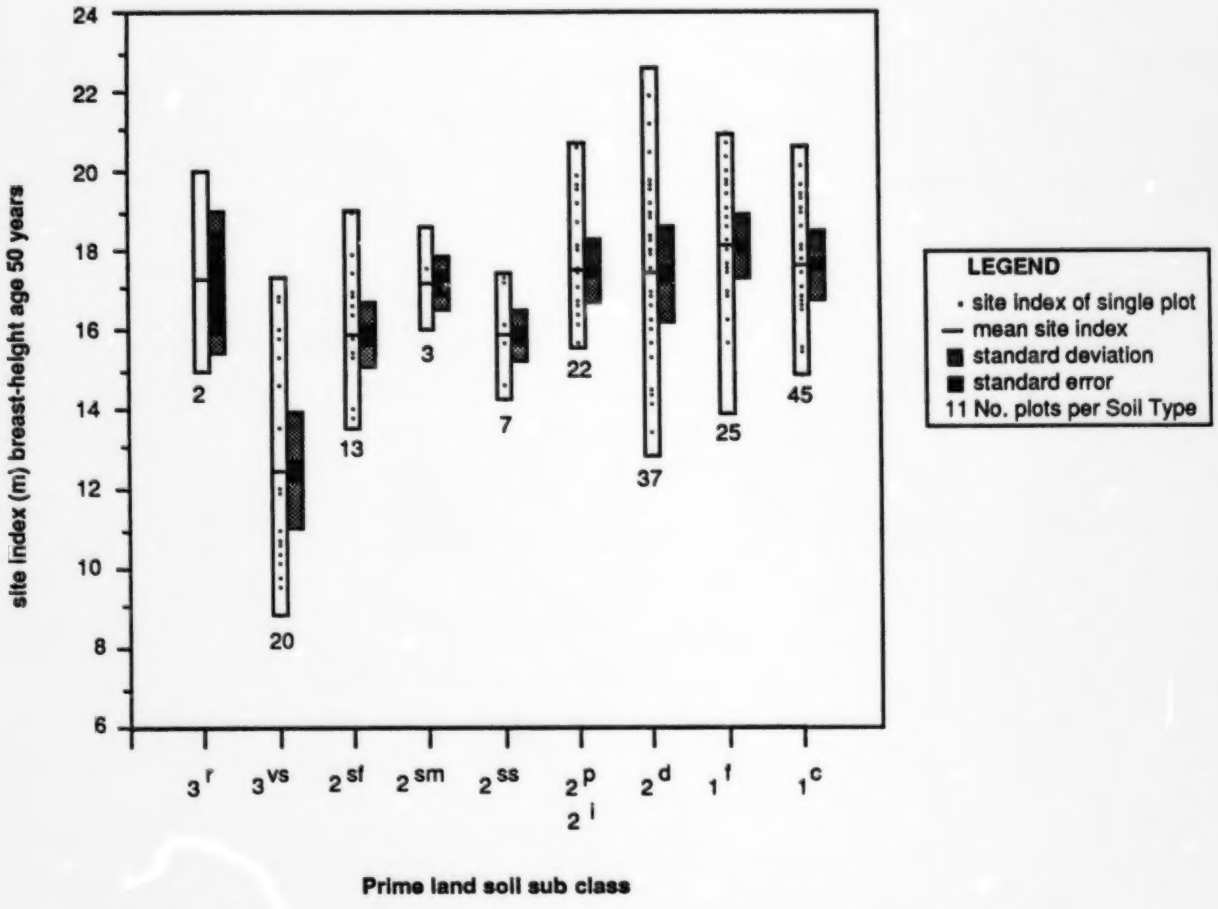

Figure 6. Scatterplot diagrams and confidence intervals for jack pine site index observations stratified by the Northern Region prime land sub classes.

DISCUSSION AND CONCLUSIONS

Prime land sub-class 3^{vs} is statistically distinct from all other prime land sub-classes on the basis of the mean and range of observed jack pine site index (site productivity) values. Sub-class 3^{vs} also displays the lowest average site productivity which was always significantly different from other sub-classes. Most primeland sub-classes had high standard deviations and standard errors of the mean, which indicates a wide range of site productivity within each sub-class. The observed jack pine site index values overlap between sub-classes to the degree that the Northern Region prime land key cannot be considered as an accurate and reliable tool for distinguishing levels of jack pine site productivity in north central Ontario.

Prime land class 2, which is defined as "intermediate" in primeness, was associated with some of the highest jack pine site index values. Prime land class 1, which is defined as "prime" actually had a lower average jack pine site index value than prime land class 2. The large variation in site index and inability to designate the very best sites, shows the incompatibility of applying the Northern Region Prime land classification to north central Ontario.

It should be concluded that the Northern Region prime land classification and key cannot accurately stratify the independent dataset into prime land classes possessing significantly different levels of jack pine site productivity which are associated with corresponding low levels of variability in jack pine site index. Therefore, its application is not recommended for distinguishing site productivity for jack pine in North Central Region.

A prime land classification should be developed for north central Ontario which identifies soil features that are significantly related to the productivity of jack pine. Most of the soil features in the Northern Region prime land key are not significantly related to the productivity of jack pine in north central Ontario, hence the great inaccuracy.

However, the soil features of soil sub-class 3^{vs} (i.e. 30 cm or less to bedrock) should be included because this sub-class is apparently useful for identifying very poor sites for jack pine.

Further studies are suggested that involve testing the Northern Region prime land classification and key with black spruce, white spruce and aspen.

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